



Atomic Force Microscopy as a tool to characterize groundwater colloids

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Groundwater colloids are involved in a multitude of biogeochemical and physicochemical processes in aqueous systems. It has long been known that such particles may act as mobile reactive carriers, resulting in either reduced or enhanced solute mobility (Totsche & Kögel-Knabner, 2004). Interactions of colloids with themselves and with the immobile solid phase, i.e. straining, flocculation, redispersion, coagulation and sedimentation not only effect the hydraulic properties, but may severely change geometric, mechanic and physicochemical properties of interfaces. Of particular importance are the nanoparticulate mineral-organic mixed phases which form from complex natural solutions. These particles are in the size of 1-100nm (lower colloidal limit according to the IUPAC colloid definition) and are composed both of mineral and organic subunits, either by the way of sorption or co-precipitation. Like locations of the formation of such mixed phases are redox-gradients typically observed in redoximorphous soils, e.g., soils affected by groundwater. The presence of organic substances during the stage of formation may not only affect mineral formation and growth, but also effect colloidal stability by additional steric stabilization forces. Thus, these nanoparticulate mixed phases may be much more stable and mobile than classical mineral, organic, or biotic colloids.

Up to now, we sampled soil and groundwater colloids from aqueous solutions at selected locations within the Thüringer Basin. The aqueous solutions were analyzed for among others chemical composition, major ions & cations, pH, EC, turbidity, TOC, DOC, surface tension, and UV-VIS absorption to assess the milieu conditions favorable or unfavorable for colloid stability. Groundwater colloids were isolated and prepared for thorough spectroscopic and spectro-microscopic analysis including Atomic Force Microscopy. Besides classical tapping and contact mode techniques to assess the geometric features (size, particle shape, surface area, and roughness) of these particles, our major interest is put on the spatial assessment of the tip sample adhesion and nanomechanical properties including elastic modulus, hardness, and energy dissipation. To do so, force curves were recorded at high spatial and temporal resolution. First results indicate that colloids formed from complex solutions in the presence of dissolved organic matter are softer and have a lower mechanic modulus than classical mineral phases. Energy dissipation as a first indication of plastic deformation increased, also. An interesting observation was also that the colloids studied so far exhibit a dual-mode size frequency distributions with maxima at 60nm and 200nm. Whether this is due to mere size exclusion and physical filtration while migrating through the porous formation or a consequence of physicochemical or biogeochemical constraints during the formation and growth of the colloids remains still open and is subject of the next step of our studies.